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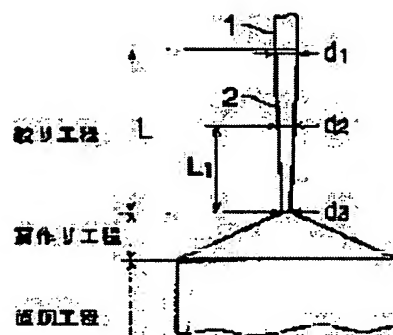
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(54) PULLING UP OF SILICON SINGLE CRYSTAL

(57)Abstract:

PROBLEM TO BE SOLVED: To prevent breakage of a crystal and minimally suppress increase of cost in a squeezing step for obtaining dislocation-free state in pulling up a silicon single crystal having crystal axis $\langle 110 \rangle$ by Czochralski process.

SOLUTION: In a squeezing step, a crystal diameter is squeezed to $< 2.0\text{mm}$ while applying magnetic field having $\geq 1,500$ gauss to a hot zone in a squeezing step. Vibration and change of temperature of the melt surface become small by application of magnetic field and breakage of crystal in solid-liquid interface which occurred from the past is prevented. In a shoulder-making step followed by the squeezing step, the strength of the applied magnetic field is gradually decreased and the strength of magnetic field is decreased to 0 until step is moved from the shoulder-making step to a drum-making step. Dislocation-free single crystal having crystal axis $\langle 110 \rangle$ is obtained by the method and increase of cost is minimally suppressed, because magnetic field is not applied in a step after the drum-making step.



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CLAIMS

[Claim(s)]

[Claim 1] An approach to pull up the crystallographic-axis <110> silicon single crystal characterized by extracting a crystal diameter to less than 2.0mm, impressing a magnetic field 1500 gauss or more, and controlling the vibration and temperature fluctuation on the front face of melt in the diaphragm process performed in advance of training of the crystallographic-axis <110> silicon single crystal by the Czochralski method.

[Claim 2] An approach to pull up the crystallographic-axis <110> silicon single crystal characterized by making magnetic field strength into zero by the time it reduces the magnetic field strength to impress gradually in the shoulder making-process following a drawing process according to claim 1 and goes into a body process.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to an approach to pull up a crystallographic-axis <110> silicon single crystal.

[0002]

[Description of the Prior Art] Although the single crystal silicon of a high grade is mainly used for the substrate of a semiconductor device, the Czochralski method (henceforth a CZ process) which pulls up cylinder-like single crystal silicon from the raw material melt in a crucible is known as one of the manufacture approach of the. Rotating [in a CZ process, fill up the crucible installed in semi-conductor single crystal raising equipment with the polycrystalline silicon which is a raw material, after carrying out the heating dissolution of the raw material at the heater formed in the perimeter of said crucible, the seed crystal attached in the seed chuck is immersed in melt, and] a seed chuck and the crucible of each other to this direction or hard flow, a seed chuck is pulled up and single crystal silicon is grown up.

[0003] Compared with the silicon single crystal of the crystallographic axis <100> currently produced in large quantities using the CZ process, <111>, and <511>, removal of a rearrangement is crystallographically difficult for the silicon single crystal of a crystallographic axis <110> in the so-called drawing process which a crystal is grown up from seed crystal and removes the rearrangement under crystal. In the silicon single crystal of a crystallographic axis <110>, the direction of the reason of the rearrangement under crystal corresponds with the shaft orientations of a vertical of seed crystal, i.e., the direction in semi-conductor single crystal raising equipment, and it is because a rearrangement is prolonged in the same <110> directions as the direction of crystal growth. The technique called the so-called multistage diaphragm which makes the diameter of a converging section thin in 3-6mm, or makes it thick as this cure, and gives irregularity is used. Drawing 2 is the mimetic diagram showing the configuration of a converging section where the multistage diaphragm was given, after it makes thin gradually the diameter of the converging section 2 following seed crystal 1, is expanded to d1 =4-6mm, and then is extracted to d2 =3-4mm. By repeating such actuation 3 times or more, a rearrangement is removed and it goes into a shoulder making-process.

[0004]

[Problem(s) to be Solved by the Invention] However, at the diaphragm process in the usual hot zone which does not impress a magnetic field, since the front face of silicon melt is vibrating, if a crystal diameter is extracted to 2.0-3.5mm under the effect of the heat convection of silicon melt, blasting of inert gas, rotation of a crucible, etc., a crystal will go out by the solid-liquid interface in many cases. Moreover, a rearrangement is unremovable, if the diameter of a diaphragm is made thick in order to prevent the piece of a crystal. For this reason, it has been thought that it is difficult to raise the silicon single crystal of a crystallographic axis <110> on mass-production level.

[0005] In order to enable silicon single crystal raising of the crystallographic axis <110> in mass-production level, two points, suppress [making it a crystal not go out in a diaphragm process and] the increment in cost accompanying this to the minimum, become an important problem. This invention was

made paying attention to the above-mentioned conventional trouble, and aims at offering an approach pulling up the crystallographic-axis $\langle 110 \rangle$ silicon single crystal which can solve said technical problem.

[0006]

[Means for Solving the Problem] It is characterized by extracting a crystal diameter to less than 2.0mm in the diaphragm process performed in advance of training of the crystallographic-axis $\langle 110 \rangle$ silicon single crystal by the CZ process, an approach pulling up the crystallographic-axis $\langle 110 \rangle$ silicon single crystal concerning this invention, in order to attain the above-mentioned purpose impressing a magnetic field 1500 gauss or more, and controlling the vibration and temperature fluctuation on the front face of melt.

[0007] Moreover, in the shoulder making-process following the above-mentioned diaphragm process, it decided to make magnetic field strength into zero, by the time it reduces the magnetic field strength to impress gradually and goes into a body process.

[0008]

[The gestalt and example] of implementation of invention In order that this invention may suppress vibration of the melt front face which happens by the convection current of melt etc. and may make small temperature fluctuation on the front face of melt, it is extracted by the magnetic field under-coating raising method (henceforth the MCZ method) for impressing a magnetic field to the whole hot zone, and processes a process. If a magnetic field is impressed to the whole hot zone by the MCZ method, the effective coefficient of kinematic viscosity of the conductor melt which intersects perpendicularly with line of magnetic force will increase, the convection current of melt will be controlled, and the temperature fluctuation on the front face of melt will decrease. For this reason, if magnetic field strength is made into 1500 gauss to the temperature fluctuation on the front face of melt when not impressing a magnetic field being about 1.5 degrees C, the convection current of melt is controlled and said temperature fluctuation can be reduced to about 0.1 degrees C. Consequently, under a magnetic field 1500 gauss or more, it becomes possible to extract thinly to less than 1.5-2.0mm, the usual a crystal diameter with implementation difficult at a CZ process, i.e., crystal diameter. Thereby, on mass-production level, it is stabilized and the crystallographic-axis $\langle 110 \rangle$ silicon single crystal of a non-rearrangement can be raised.

[0009] Although it becomes possible to extract by the above and to advance a process good, the cost rise by impression of a magnetic field is not avoided. For this reason, the technique which reduces a magnetic field gradually at the back process of a diaphragm process is needed for establishment of mass production technology. If the magnetic field strength impressed to the whole hot zone is reduced gradually and it goes, since the convection current of melt will begin to take place and the temperature on the front face of melt will begin to rise, there is an inclination for a crystal diameter to become thin. Then, it is desirable to reduce a magnetic field to 0 gauss, by the time the shoulder making-process in front of a body process is completed rather than it reduces a magnetic field after going into the body process which raises a single crystal, with a predetermined crystal diameter maintained. If it does in this way, control of the crystal diameter in a body process will become easy.

[0010] Next, the example of an approach to pull up the crystallographic-axis $\langle 110 \rangle$ silicon single crystal concerning this invention is explained with reference to a drawing. Drawing 1 is the mimetic diagram showing the upper limit part of the crystallographic-axis $\langle 110 \rangle$ silicon single crystal manufactured by the approach to pull up this invention.

[0011] Vacuum suction of the inside of the chamber of semi-conductor single crystal raising equipment was carried out to 14 - 20Torr, and Ar gas for 3 - 5x10⁻²Nm³/was introduced as inert gas. The 1500-4000 gauss magnetic field was impressed to the whole hot zone, after immersing and familiarizing seed crystal 1 with melt, the seed chuck which is not illustrated was pulled up gradually, and was extracted, and the process was started. Crystal diameter d1 of the converging section 2 at the time of drawing process initiation It is 8mm, this is gradually made thin, and it is a diameter d2. 2.0mm and crystal diameter d3 at the time of diaphragm process termination (diameter of min) It could be less than 1.5-2.0mm. The overall length L of a converging section 2 was set to 50-300mm. the inside of said die-

length L -- a crystal diameter -- the part d2, i.e., the crystal diameter, of less than 2.0mm from -- d3 up to -- die length L1 It is 10-100mm. Moreover, the crystal diameter considered the crystal raising rate in a less than 2.0mm part as a part for 5.0-6.0mm/.

[0012] When pulling up the single crystal whose diameter of the body section is 103mm, made into 30 - 100 minutes time amount which the shoulder making-process following a diaphragm process takes, it was made to be proportional to said duration, and the magnetic field was reduced gradually. For example, when magnetic field strength made a shoulder making-duration 100 minutes by 1500 gauss, 15 gauss a part for /and magnetic field strength was [a shoulder making-duration] 30 minutes in 4000 gauss, came out for 140 gauss/comparatively, a magnetic field was reduced gradually, a shoulder making-process was completed and a crystal diameter amounted to 103mm, it controlled so that a field served as zero.

[0013] As a result of using the above-mentioned approach, the piece of the crystal in a diaphragm process was not generated, but the stable diaphragm was able to be performed. Moreover, a rearrangement was not accepted in the obtained crystallographic-axis $\langle 110 \rangle$ silicon single crystal. This is because the rearrangement was removed, when the crystal diameter of a converging section 2 set the die length of a less than 2.0mm part to 10mm or more in the diaphragm process.

[0014]

[Effect of the Invention] Since the silicon single crystal of a crystallographic axis $\langle 110 \rangle$ has the same direction and crystal growth direction of a rearrangement of [under crystal], it was difficult to be stabilized at a diaphragm process and to attain non-rearrangement-ization, it was made unsuitable for mass production, and is behind in establishment of mass production technology compared with the silicon single crystal of a crystallographic axis $\langle 100 \rangle$, $\langle 111 \rangle$, and $\langle 511 \rangle$. And when $\langle 110 \rangle$ was pulled up with the conventional method, solid-liquid interface pieces occurred frequently, 90 became poor among 100, and ten have raised at last. (10% of rates of an excellent article)

However, operation was enabled to extract to the difficult crystal diameter of less than 1.5-2.0mm in the conventional CZ process by impressing a magnetic field 1500 gauss or more at a diaphragm process, consequently raising of the silicon single crystal of a crystallographic axis $\langle 110 \rangle$ became easy, and when carried out, 100 became an excellent article among 100. (100% of rates of an excellent article) Moreover, before reducing a magnetic field gradually at the shoulder making-process of degree process and going into a body process, it can stop to a necessary minimum cost rise by making a field into zero. Compared with the conventional MCZ method, electrical charges can be managed below with one half, and economical effectiveness is also great. Therefore, the fertilization of $\langle 110 \rangle$ wafers on which high density can be made to accumulate a device is attained.

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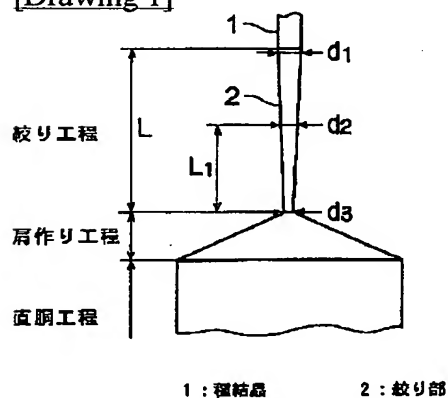
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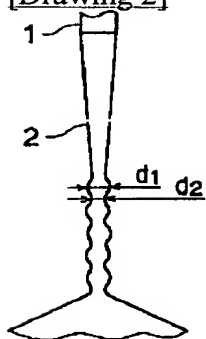
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DRAWINGS

[Drawing 1]



[Drawing 2]



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